Pilema octopus, *Pelagia phosphora*, and three specimens of *Cassiopea* were also carefully examined, but no trace of gonadial grooves could be found in any of them.

In conclusion I desire to tender my warmest thanks to Lord Avebury for his kindness in nominating me to the use of a table at the Plymouth laboratory during the month of August, and also to the laboratory officials for the excellent facilities which were afforded me for the collection and examination of specimens during my stay there.

EXPLANATION OF PLATE XXIV.

Gonadial grooves of *Aurelia aurita*.

All the figures are camera lucida drawings. Fig. 2 is with Leitz $\frac{1}{12}$ oil-immersion objective and No. 4 eyepiece.

Fig. 1 (×40). Section passing through groove, at a point just within the gastric pouch. Thick buttressing mesoglœa on either side of the groove. Mass of male cells lying within the groove.

Fig. 2 (×1050). Portion of section in fig. 1 showing spermatozoa and nutrient cells in the groove.

Fig. 3 (×46). Section passing through main passage to a gastric pouch, showing gonadial groove in the floor in an almost median position bounded on either side by endodermal epithelial folds. Between the latter is a mass of eggs.

Reference Letters.

b.w, body-wall or mesoglœa; *d.n.c*, disintegrating nutrient cells; *e*, epithelium lining gonadial groove and main passage; *g.g*, gonadial groove; *g.p*, gastric pouch; *n.c*, nutrient cells; *o*, eggs; *s.p*, spermatozoa.

4. The Tuberculin Test in Monkeys: with Notes on the Temperature of Mammals. By Arthur Erwin Brown, D.Sc., C.M.Z.S., Secretary of the Zoological Society of Philadelphia.

[Received November 25, 1908.]

(Text-figures 1–4.)

For many years previous to the introduction of a rigorous quarantine system for incoming monkeys, and of exact measures for the detection of tuberculosis in the Zoological Gardens at Philadelphia, it is believed that at any given time from one-fifth to one-fourth of the monkeys in the collection were tuberculous. Indeed, there have been at least two periods when, under what appeared to be an infection of especial virulence, the death-rate exceeded this average.

A more or less similar experience has been that of the older Zoological Gardens in Europe and America.

In March 1905, upon the opening of the Laboratory of Pathology in the Gardens at Philadelphia, a series of observations was begun by Dr C. Y. White, at that time the Society's pathologist,

and myself, having in view the possible control of this disease. It was known that many of the monkeys coming to the Gardens from the hands of dealers were already infected, and that even in advanced stages they are often of healthy appearance and seldom give reliable external indications of the disease.

The old stock of monkeys had been undergoing a period of acute infection, and without exception they were removed from the Monkey House and for the most part used for experimental purposes, the building itself being thoroughly cleaned and disinfected with formaldehyde vapour. Since then every monkey reaching the Gardens has been placed in a quarantine room, and only those that successfully passed the test of sub-cutaneous injection of tuberculin have been sent to the Monkey House for exhibition. The use of tuberculin has thus been solely for a diagnostic purpose.

Many difficulties were encountered in the early stages of the work, mainly due to the irregularities of temperature in monkeys, and to our initial ignorance of what should be regarded as normal in healthy animals, as well as of the kinds of reaction to be expected in tuberculous cases.

These obstacles were for the most part overcome through careful study of the conditions shown on autopsy in a large number of animals, in connection with the corresponding temperature charts, and it is now felt that the method and the results have reached a large measure of certainty.

The individual variations in temperature are marked, and it is frequently necessary to take a record (rectal in all cases) daily for several weeks before it settles down to approximate regularity, which in our experience is about 101° or 102° Fahr. in the mid-afternoon. This is slightly higher than the 38° Cent. (100·4° F.) assumed as a normal by Simpson and Galbraith *, but it is probable that the difference may be accounted for by the fact noted by us and also shown by those authors, that excitement and muscular effort definitely raises temperature in these animals †. The monkeys used in their observations were handled for a much longer period than ours, and they were able to select those that became relatively indifferent to the usage and restraint involved.

Although we have accepted the above standard as normal, cases have occurred where monkeys have shown temperatures never below 104° at the daily maximum, and are still living and to all appearance in good health.

An important fact was early determined by a sequence of

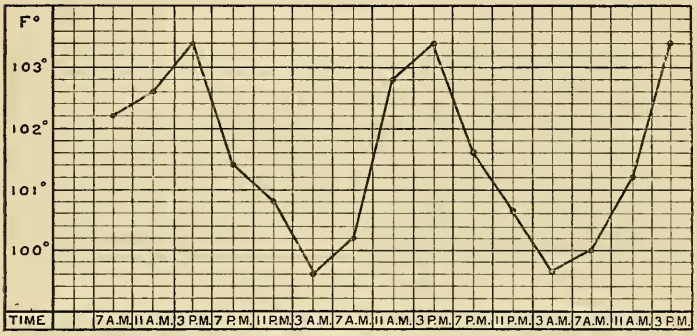
* Trans. Royal Soc. of Edinburgh, xlv. pt. 1, p. 98 (1906).

† An interesting instance is afforded by a lot of five monkeys subjected to the test a few weeks ago. Temperatures were taken daily for two weeks before injection and all ran with unusual regularity. On September 25th, near the end of the period, each chart showed a sharp elevation of from ·4° to 1·2° F. It was found upon inquiry that the attendant who usually took the temperatures was absent on that day, and the duty fell to another man who had experience in the work but was less gentle in handling the animals, and who, moreover, was quite unknown to this particular lot.

records taken at intervals of four hours during several days, in the existence of a marked daily rhythm or range in the case of every species of monkey examined, the high point being reached toward 3 P.M., about which time a steady fall sets in amounting to three or four degrees by 3 A.M.; from then it rises again to the afternoon maximum. This daily range is shown in Chart A (text-fig. 1), and is in substantial agreement with the results reached by Simpson and Galbraith. It should be mentioned that few charts are as symmetrical as the one selected.

Text-fig. 1.

Chart A.



Cercopithecus pygerythrus ♂ adult.

Temperature chart showing normal daily curve.

In the beginning temperatures were taken for only twenty-four hours after injection, but it was found that reactions are sometimes delayed until the second day, and an essential gain was made in extending the observation period to forty-eight hours.

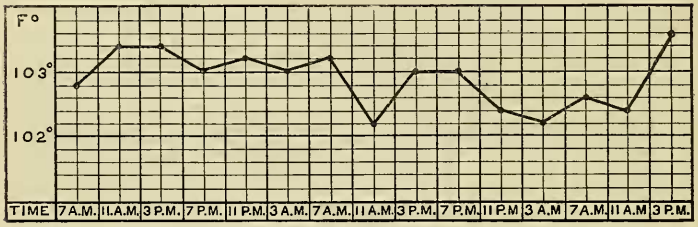
The course of procedure now followed in the tests is that when the daily temperature of the individual monkey has settled down to a somewhat regular course, an injection is made under the loose skin of the lumbar region of from $\frac{3}{4}$ to 2 milligrams of Koch's original tuberculin. This dose is only exceeded in case of exceptionally large animals, such as anubis or chacma baboons, which have received as much as 3 mgs. Injection is made in the forenoon, in order that a rise of temperature concurrent with the upward tendency culminating about 3 P.M. may be noted. Temperatures are then taken at intervals of four hours for two full days. The hours we have selected as best indicating on the chart the daily course, are 7, 11, and 3.

With healthy monkeys we have observed no change in the degree or course of the daily rhythm, following injection, nor ill results of any kind.

In tuberculous subjects the usual result is a general rise of temperature within the first twelve-hour period, though in a few cases the rise has not appeared until the next day, or in many cases a complete destruction of the daily curve ensues, with or without a general rise. This last condition clearly represents the balance reached in the struggle between two opposing tendencies, the upward one due to tuberculin reaction and the downward one which is the normal nightly course, and in meaning is equivalent to a definite rise. Chart B (text-fig. 2) is of this character. In this case, a young rhesus monkey, the temperature before injection ranged from 102·6° to 104·4°.

Text-fig. 2.

Chart B.



Macacus rhesus ♂ juv.

Temperature chart showing tuberculous reaction destroying daily curve, with no general rise.

It may be noted that in every case showing reaction of either type, autopsy has shown tuberculous lesions*.

The charts most difficult of interpretation, however, in the study of which quite a number of healthy monkeys were sacrificed, are those not infrequent ones in which there is no definite rise in temperature, and no complete destruction of the night drop, but only more or less of a failure to properly complete it. These cases are now held over for retesting after an interval of six or eight weeks, and occasionally the second test gives a positive reaction. It has not infrequently happened that monkeys have been retested as many as three times before a final conclusion was reached. Such charts call for nice discrimination, and, even with the most expert, in them must always lie a possibility of error.

In a few very advanced stages of general tuberculosis there was no reaction rise, and the daily curve was completed, so that a serious certainty of error would arise were it not for the fact that

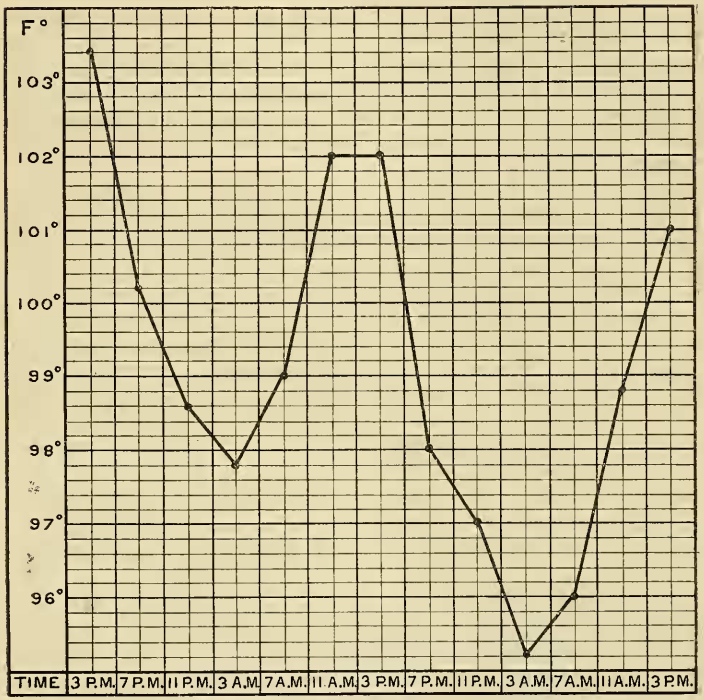
* I am not prepared at this time to suggest an explanation of the difference between our results and those announced by the Royal Commission on Tuberculosis (Second Interim Report, p. 44, London, 1907). If anything has been certain in our experience, it is that in not a single case of definite reaction has autopsy failed to show tuberculosis.

in every such case that we have observed, the whole temperature after injection dropped conspicuously and death speedily followed.

Chart C (text-fig. 3) represents such a case.

Text-fig. 3.

Chart C.



Cercopithecus sabæus ♀ adult.

Temperature chart showing marked post-injection fall in advanced tuberculosis.

These advanced subjects, the only ones in which positive reactions have not been given in presence of tuberculosis, do not impair the practical value of the test, for they are quickly eliminated by death.

In one respect, mainly of pathological interest, much remains to be determined, in the proportion between the degree of reaction and the extent of the tuberculous lesions. So far, we have found an apparent lack of any such constant relation except as noted in very advanced cases, in which, under the large doses of tuberculin used, temperature has made a marked drop.

The necessity for an inflexible practice in the interpretation of

charts cannot be too strongly stated. It has been followed relentlessly throughout our work, and every doubtful case was in the end decided against the monkey. In every case when an animal was condemned, it was etherized and brought to the post-mortem table.

A thoroughly complete system of prevention would perhaps require the retesting of each monkey in the exhibition series at least once a year, but this is no small undertaking in an extensive collection, and we have restricted the practice to those concerning which suspicion arises based on ill-health or other indications. These are immediately removed to the Laboratory and reinjected. If the reaction is bad, the monkeys occupying the same cage are at once taken to the Laboratory and put through the same course. The infected cage as well as the adjoining ones are then thoroughly disinfected.

Quite recently I have made a study of the history of every monkey and lemur that has been tested since March 1905, in the light of the records now in the Laboratory, consisting of two hundred and sixty-seven post-injection temperature charts, and complete post-mortem records of nearly one hundred cases.

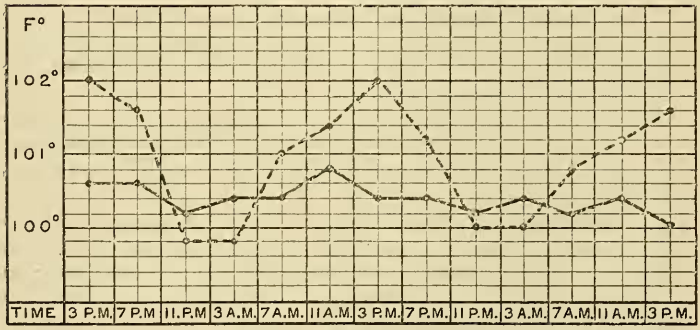
Up to November 1908, the test has been applied to one hundred and sixty-three newly arrived monkeys belonging to *Presbytis*, *Cercopithecus*, *Cercocebus*, *Macacus*, *Cynopithecus*, *Papio*, *Ateles*, *Cebus*, *Chrysothrix*, *Callithrix*, and including a few of the genus *Lemur*. Of these, one hundred and four passed the test and were sent to the Monkey House. Of those not passed, twenty-five were promptly condemned on their reactions and showed tuberculosis on autopsy. The remainder either died from other causes while in quarantine, or were etherized to learn the meaning of dubious charts, during the early and experimental stages of the work.

Of the one hundred and four originally passed, ten have developed tuberculosis during the three and a half years that have elapsed. Three of these died in the exhibition cages, giving no sign of ill-health. The others were detected and returned to the Laboratory, where they were either etherized or secluded. Seven of these cases are traceable with reasonable certainty to two infections from monkeys which were passed early in the tests on twenty-four hour records, whose charts would be considered doubtful in the light of later experience. The three remaining ones were also passed early in the tests, two of them on rather uncertain charts, that of the third being of good quality though somewhat irregular according to our present standards. This monkey, a male *Cercopithecus ruber*, tested in November 1906, died six weeks later from nephritis and fatty degeneration of the liver, and showed early miliary tuberculosis of the intestinal submucosa. With this exception, no monkey passed since February 1906 has as yet shown signs of tuberculosis, and more than a year has elapsed since the last one exhibiting it was removed from the Monkey House on October 16th, 1907.

The history of this case, a male *Cercocebus fuliginosus* (Number 59), is interesting, not only because it was one of the first lot tested, but as an example of the need for unceasing vigilance. It reached the Gardens on March 29th, 1905, and had a temperature taken almost daily until June 28th, the range being from 100·6° to 103·8°. On the last date it was injected and gave a twenty-four hour temperature which appears good, but not being fully understood the animal was held over and reinjected on August 8th, at which time it was passed, again on a twenty-four hour record. In January 1906 it seemed unwell and was returned to the Laboratory for retesting, on which occasion the forty-eight hour chart was good, with trifling irregularities. It was kept under observation until March 6th, when it was returned to the Monkey House. Later in that month three others of the same species, originally passed in December 1905, were removed for retesting and found to be tuberculous, one of them (No. 62) having been the source of infection, as is indicated by present reading of the charts. Number 59 remained on exhibition in apparently good health for nineteen months, until October 16th, 1907, when it was removed to the Laboratory, dying three days later with general tuberculosis. After March 1906 this animal was not exposed to infection from other monkeys, and it is probable that it contracted the disease at that time from its three cage-mates, which were found to be tuberculous several weeks after its return.

Text-fig. 4.

Chart D.



Lemur varius ♀ adult.

Non-tuberculous temperature charts. Unbroken curve taken April 9th–11th, 1907; broken curve taken July 1st–3rd, 1907.

Progress of the disease is usually much more rapid with monkeys than in this subject, and it is of course possible that it may have been a sporadic case communicated by human agency.

It cannot be said that the results reached with lemurs are equally exact. Indeed, at the present time, we are not disposed to rely much upon the charts in this group, except in cases of positively bad reaction. The greater frequency of doubtful cases here, than with monkeys, is primarily due to the greater amount of normal individual irregularity, especially in regard to the night drop. This is true even of diurnal species, as the genus *Lemur*, in which it is sometimes well marked, at others absent. To illustrate this two post-injection curves are given in Chart D (text-fig. 4, p. 87), of a female *Lemur varius*, on the first of which, taken in April 1907, had she been a monkey she would have been unhesitatingly condemned. In July she gave a good chart, differing from monkeys only in somewhat advancing the hour of the night minimum. She died September 8th, without any trace of tuberculosis.

There is some reason to believe that on the whole lemurs are less susceptible to infection through the usual channels than monkeys, though by no means immune.

At the present time, after three and a half years of systematic observation, the findings we believe to be justified by the fact that more than a year has passed without evidence of the existence of tuberculosis in the Monkey House, are these :—

1. In every case where a positive reaction has followed injection we have found tuberculosis on autopsy.

2. In negative charts, where no rise of temperature appears, nor perturbation of the daily rhythm, we have had no reason to believe that the disease exists. It has been absent in every such case after a forty-eight hour observation, where animals have subsequently come to autopsy.

3. In intermediate charts, neither positive nor negative, safety lies in nicety of judgment on the part of the observer, this being mainly a matter of experience. But a very small percentage of such cases have been tuberculous.

4. In very advanced cases of general tuberculosis the usual reaction does not always follow injection, but we have found such cases to be indicated by a notable drop in temperature, and proved by early death.

The difficulties in the way of applying the temperature reaction test generally throughout a zoological collection are obvious. The effort, risk, and various uncertainties involved in the frequent handling of large and powerful ungulates or carnivores, to procure the indispensable data, are so great that it is probably impossible.

In this aspect the eye test of Calmette, and skin tests, such as that of Lignières, seemed to be of some promise; but it is unfortunately true that experiments made by the present pathologist, Herbert Fox, M.D., with these tests upon monkeys known to be tuberculous, have not fulfilled expectations.

We are naturally led to the general subject of mammalian

temperatures, and a few notes may be given consistently with the purpose of this paper, together with a list of temperatures that have been taken with a view to possibly more extended work with tuberculin.

By artificially causing monkeys to turn night into day in all that concerned their activity, Simpson and Galbraith reversed the daily curve of temperature, the low point occurring in the afternoon, the high point in the early morning. This result, together with the irregularities we have found in diurnal lemurs, led me to observe the course in two nocturnal species: *Perodicticus potto*, in which the record for twenty-four hours proved to be: 3 P.M., 97·4°; 7 P.M., 99·2°; 11 P.M., 100°; 3 A.M., 99·8°; 7 A.M., 98°; 11 A.M., 97·6°; 3 P.M., 97·8°: and *Galago senegalensis*, in which the 3 P.M. record was 100·6°, the 3 A.M. 102·6°. A single observation previously made on *Galago crassicaudatus* at 3 P.M. gave 98·8°. This being low for primates, it is probable that it is near the minimum point in the daily curve of this species also, and that the record obtained from the Potto represents the normal in nocturnal lemurs, corresponding in its main features with Simpson and Galbraith's reversed curves in monkeys, the chief difference being that both high and low points come rather earlier.

It seems, therefore, that the temperature drop in primates is an easily induced physiological result of decreased activity, which reaches its lowest limit during the period habitually allotted to sleep, and that the above condition should also be true of the night-monkeys, *Nyctipithecus*, but conclusions from five records taken from two examples of *N. trivirgatus*, about 3 P.M., are obscured by their irregularity. These were 102·2°, 101·5°, 100°, 99·8°, 99·4°. Further investigation of the complete curve in this genus will be of interest when occasion offers.

The temperatures following were taken with tested thermometers, and nearly all were checked by three observers. Whether or not, or to what extent, they were affected by excitement, as in monkeys, can be determined only by a more extensive series of observations than we have yet been able to undertake. The records were taken between 10 A.M. and 4 P.M. The temperature of the building in which the kangaroos were kept was 50°, the others ranged from 63° to 67°, but, excepting primates, within these limits neither the hour nor the surrounding temperature had any perceptible influence in the many cases where the same animal was tested repeatedly under different conditions.

Bearing in mind, however, the reversed daily curve in night-lemurs, it is significant to observe that animals of known nocturnal habit, such as *Cercoleptes*, *Arctictis*, *Paradoxurus*, and *Mephitis* among carnivores, and *Peromyscus*, *Dipodomys*, *Capromys*, and *Dipus* among rodents, give afternoon temperatures distinctly lower than is common in diurnal species of their respective orders.

	Number of Specimens.	Maximum.	Minimum.
PRIMATES.			
Nyctipithecus trivirgatus ♂ ♀	2	102·2°	99·4°
Hapale jacchus ♂	2	102·8	102
Perodicticus potto ♂	1	97·4	
Galago crassicaudatus ♂	1	98·8	
„ senegalensis ♂	1	100·6	
CARNIVORA.			
Nasua rufa ♂	1	102·6	98·8
„ narica ♂	1	100·8	
Procyon cancrivorus ♂	2	100·2	99·2
„ lotor ♂	1	103·4	
Cercoleptes caudivolvulus ♂	1	97·5	
Bassaris astutus ♂	1	100·2	99
Viverra megaspila ♂	1	100·5	
Viverricula indica ♀	1	102	
Arctictis binturong ♂	1	99·2	
Paradoxurus niger ♂	1	98·8	
„ hermaphroditus ♂	1	97·8	
Nandinia binotata ♂	1	101	
Herpestes mungo ♂	1	103	
Mustela furo ♀	1	102·2	
Galictis barbara ♂ ♀	2	105·6	104·2
„ vittata ♀	1	101	
Mephitis mesomelas ♂ ♀	2	97·8	97·4
Angora Cat ♂	1	101·2	
RODENTIA.			
Dipodomys spectabilis ♂	1	99·4	
„ ambiguus ♂	1	96·8	
Dipus jaculus ♂	1	99·2	
Peromyscus texensis ♀	1	97·8	
Capromys pilorides ♂	1	98·4	95·6
Myopotamus coypus	1	101·8	99
Dasyprocta azaræ ♂	1	102·4	102
„ prymnolopha ♂ ♀	2	102·2	101·6
„ aguti ♂ ♀	2	102·2	100·2
„ acouchy ♀	1	102·2	101·5
PROBOSCIDEA.			
Elephas indicus old ♂	1	97·5	96·2
„ „ old ♀	1	97·5	97·2
„ „ young ♀	1	97·8	96·4
UNGULATA.			
Mazama rufa ♀	1	100·8	
Cervulus muntjac ♂	1	101·4	
Anoa depressicornis ♂	1	102	
EDENTATA.			
Cholœpus hoffmani	1	94·2	
Dasypus sexcinctus ♀	1	93·4	90
„ novemcinctus ♂ ♀	2	93	91·6
MARSUPIALIA.			
Didelphys virginiana ♂	1	94·4	90·8
Dasyurus maculatus ♂ ♀	2	93·8	90
Phalangista vulpina ♂ ♀	4	97·8	91·6
Macropus giganteus ♀	1	96·8	94·4
„ robustus ♂ ♀	2	95·2	
„ ruficollis ♂	1	96·4	
MONOTREMATA.			
Echidna aculeata ♂*	2	87	86

* R. Owen (P. Z. S. of London, 1845, p. 81) gives the temperature of the echidna as 85°.